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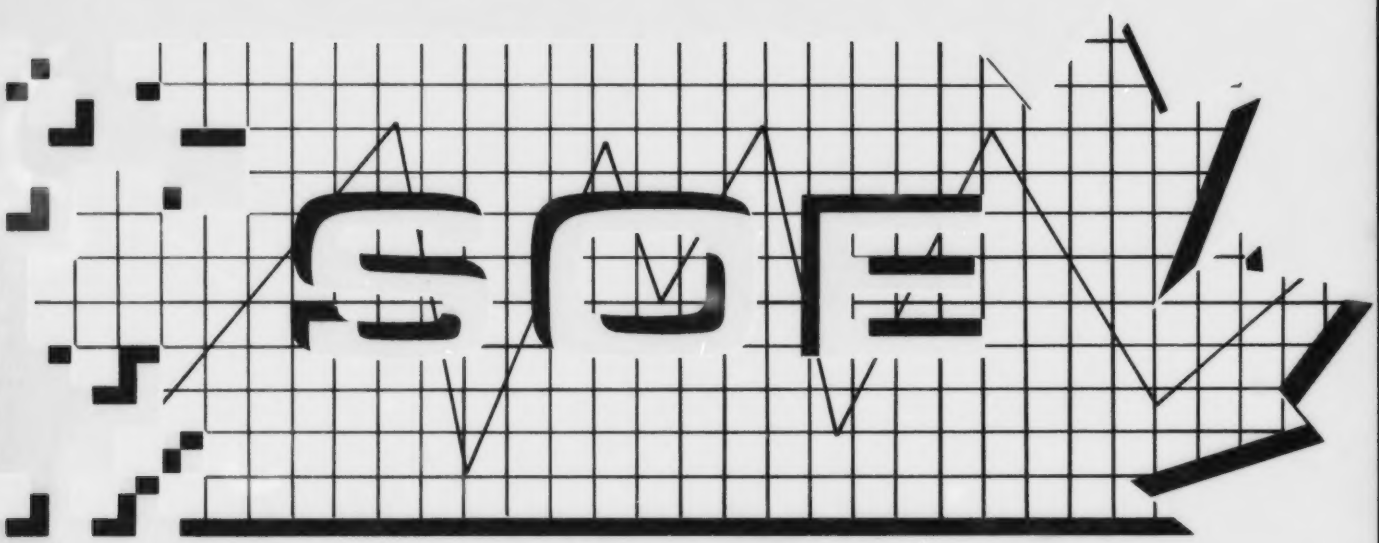

Strategies and Scientific Methods Division
State of the Environment Reporting Branch
Canadian Wildlife Service

Canada

THE USE OF INDICATORS
TO SHOW THE STATE AND RECENT TRENDS
IN SUSTAINABLE DEVELOPMENT
IN CANADA

(Draft)

Report No. 10

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TABLE OF CONTENTS

		Page
1.	INTRODUCTION	1
2.	REQUIREMENTS FOR SUSTAINABLE DEVELOPMENT	3
3.	COMPONENT ACTIVITIES OF ECONOMIC DEVELOPMENT	7
4.	IDENTIFYING QUANTITATIVE MEASURES OF SUSTAINABILITY	10
5.	LIST OF INDICATORS	14
	5.1 Resource Extraction	14
	5.2 Resource Processing	23
	5.3 Resource Consumption	25
	5.4 Provision of Services and Infrastructure	27
	5.5 Resource Protection	29
6.	APPLYING SUSTAINABLE DEVELOPMENT INDICATORS: AN EXAMPLE FROM THE FORESTRY SECTOR	31
APPENDIX:	SUSTAINABLE DEVELOPMENT INDICATORS: INFORMATION SOURCES AND EXPLANATORY NOTES	

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1. INTRODUCTION

The Brundtland World Commission on Environment and Development called on all nations to use resources sustainably, through "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." Canada's federal and provincial governments have endorsed the sustainable development concept, and the National Task Force on Environment and Economy has recommended an approach to make the concept a reality. But how will Canadians know when sustainable development has been achieved? How can we measure progress toward the ideals of the Brundtland Commission? We require a suitable information base. We need benchmark data with which to evaluate development impacts on the environment, and we must have measures of performance by which to guage sustainability of resource use.

The federal State of the Environment (SOE) Reporting Program was established to provide information on the status and trends of environmental quality and natural resource use. A major objective of the program is to encourage sustainable use of natural resources. Thus it is appropriate for the SOE program to identify particular measures or indicators of sustainability and to apply these indicators in a Canada-wide study of economic development.

This report describes an approach for such a study. It presents a framework for measuring changes and trends in socio-economic activities as indicators of a move towards sustainable development. The rationale for this approach is the acknowledged need to adapt socio-economic activities to the natural limitations that govern life on earth.

Developing the study framework involved four major steps:

1. identifying basic requirements for economic development to be sustainable--a set of standards of sustainability by which economic activity may be evaluated;

2. listing the different activities which together comprise economic development in Canada;

3. applying the standards developed in step 1 to the activities identified in step 2, to determine quantitative indicators of trends in sustainability of economic development;

4. identifying data sources for applying the sustainability indicators; and

5. describing a proposed reporting format through the use of an example from the forestry sector.

2. REQUIREMENTS FOR SUSTAINABLE DEVELOPMENT

To develop a comprehensive set of sustainable development indicators it is first necessary to define the term "sustainable development" and to describe the concept in some detail.

Sustainable development is defined here as: the utilization of resources and the environment to optimize economic and other societal benefits today while not damaging prospects for their use by future generations.

To achieve sustainability, development must meet four basic objectives:

1. protecting natural systems that support life on earth (atmosphere, water, soils, living organisms);

2. preserving genetic diversity;

3. using renewable resources at a sustainable rate; and

4. foreclosing as few future options as possible in using non-renewable resources.

Each of these objectives suggests a number of standards by which to measure development activity.

Standards for Protecting natural systems:

1. Prevent degradation of the atmosphere, water and land by pollution or physical disturbance.

2. Maintain processes that drive the systems (flows of energy and matter over time and space).

3. Optimize allocation of resources among conflicting interests.

Standards for Preserving genetic diversity:

1. Maintain representative ecosystems.

2. Prevent extinction of individual species and sub-species.

3. Prevent loss of genetic diversity within species.

Standards for Sustaining Renewable Resource Use:

1. Harvest at levels which allow resources to be replenished without adverse environmental effects or any reduction in productivity of the resource.

2. Take into account effects on other components of the ecosystem.

3. Renew resources (by replanting, encouraging regeneration).

4. Ensure efficient resource use.

Standards for Sustaining Non-renewable Resource Use:

1. Control the rate of depletion (minimize waste, optimize allocation).

2. Develop environmentally benign substitutes for scarce resources and for those which have adverse effects on the environment.

3. Use non-renewable resources economically and efficiently.

4. Use renewable rather than non-renewable resources whenever possible.

To determine the overall sustainability of development in Canada, the above standards must be applied to the full range of activities which comprise economic development. This requires identification of specific quantitative measures which can be applied to economic activities in relation to the standards. In other words, it is necessary to identify particular measurements which can be made to guage the sustainability of society's use of the environment. These measurements must be repeated over time to determine our progress toward sustainable development.

Section 3 provides a breakdown of economic development in categories within which to apply the standards of sustainability, and Section 4 describes the kinds of indicators which can be applied to the different categories. Section 5 lists specific quantitative measures which can serve as indicators of sustainability in Canada.

3. COMPONENT ACTIVITIES OF ECONOMIC DEVELOPMENT

Economic development involves a multitude of activities ranging from exploration for resources to consumption of manufactured products and provision of all the services on which consumers and industry depend. Each of these activities consumes natural resources, produces wastes and each may impact on the environment in a variety of ways.

Determining the overall sustainability of economic development will require a large number of indicators of performance. A systematic breakdown of economic development into component activities will help in preparing a comprehensive list of indicators of sustainability. The approach used here is to define five broad categories of development, with each category including numerous related activities. The categories are: 1) resource extraction, 2) resource processing, 3) resource consumption, 4) provision of services and infrastructure, and 5) resource protection.

Resource Extraction

Resource extraction encompasses all the activities involved in providing raw materials for industry. This involves exploration, harvest and transportation of raw materials,

as well as resource enhancement (measures to restore, replenish or increase productivity of renewable resources for future use). Resource extraction includes the renewable resource sector (agriculture, fisheries, forestry and hydroelectric development) and the non-renewable sector (mining and fossil fuel development).

Indicators of sustainable development should relate to the many resource-consuming and waste-producing activities which are common to the various sectors: land clearing; construction of roads, buildings and other facilities; operation of equipment; and transportation and accommodation of workers. Indicators must also relate to activities which are unique to particular sectors (spruce budworm spraying in forestry, land flooding in hydro development, offshore drilling in fossil fuel development).

Resource Processing

Resource processing includes all the activities involved with converting raw materials into products used by society. Broad categories in this sector are: forest product processing, metal smelting and manufacturing.

Resource Consumption

Resource consumption includes all the activities involved in the use of resource products, for food, clothing, shelter and recreation. Goods consumed are both renewable and non-renewable, and include processed and unprocessed forms of: flora (domestic and wild); fauna (domestic and wild); land; minerals; natural gas; oil; and water.

Provision of Services and Infrastructure

A major component of economic development is the provision of the many services and facilities which go to support modern society. Categories of activity here include: government, business and professional services; generation and supply of electricity; and transportation.

Resource Protection

Governments and the private sector operate a wide range of programs and facilities which are intended to conserve or protect natural resources. The resource protection sector includes: facilities to maintain plant and animal stocks (arboreta, botanical gardens, herbaria and zoos); parks and reserves.

4. IDENTIFYING QUANTITATIVE MEASURES OF SUSTAINABILITY

Identifying indicators of sustainability requires some basic assumptions:

- there are different means or approaches to carry out specific economic development activities;
- these different approaches vary in the degree of impact on the environment and the drain placed on natural resource stocks; and
- these differences can be measured with some confidence.

The forestry sector provides an example of such differences in approach to a particular activity. Forest harvesting can be done in a number of different ways, including clearcutting and selection cutting. These approaches can differ significantly in their environmental impact and long term effect on forest productivity. The impacts can be measured using the appropriate indicators (see Section 6).

Specific measures of the sustainability of economic development should show how alternative approaches to an activity differ in environmental impact, and should show the amount or frequency of use of the different approaches. In addition, there is a need for other broad measures of resource use in Canada: What is happening to our stocks of wood, oil, gas, wildlife and farmland? A

comprehensive analysis will also require information on the types and amounts of waste products and pollutants generated by Canadian society. Finally, we need effective indicators of the condition of the receiving environment, to determine the ultimate impacts of economic activities and to judge the effectiveness of our efforts to achieve sustainability.

These diverse information needs call for a variety of types of sustainable development indicators:

1. Measures of the relative amounts, importance, or frequency of "sustainable" versus "non-sustainable" activities--such measures could be used where there are alternative approaches to a particular activity, and one approach is clearly better for the environment. An example is the use of chemical pesticides versus biological controls.

2. Measures of specific factors which indicate the sustainability of an activity--these factors include energy efficiency, waste production and amounts of effluents produced. An example is the rate of water withdrawal and consumption by mining.

3. Broad measures of resource consumption by society--these would include Canada-wide trends in the use of minerals, wood fiber, oil, natural gas and electricity. These figures could be expressed per capita or in total, and would reflect the overall stocks within specific resource sectors. An example is the oil and gas life index.

4. Indicators of environmental quality--these would be measures of the condition of the environment: water and air quality; survival of plant and animal species; and soil productivity. These measures would reflect the sustainability of economic activity by showing the environment which provides the raw materials and receives the wastes of this activity.

In producing a state of the environment report on sustainable development, choices among these four types of indicators will be dictated both by the nature of the economic activity being measured and by the available data. It may be difficult to identify suitable indicators within each category for every economic sector, but in combination, those measures which can be applied should provide an adequate relfection of the sustainability of the sector. In agriculture, for example this report identifies fourteen type 1 and 2 indicators, but none have been

identified in categories 3 or 4. However, the measures which have been developed should provide a good overall assessment of the sustainability of Canadian agriculture.

5. LIST OF INDICATORS

This section presents 99 different measures of sustainability which can be applied to the economic development activities described earlier. This list is comprehensive, but not exhaustive. Other indicators could be developed to provide more detailed analyses of particular economic sectors, but the measures described here will together provide a good overall picture of progress toward sustainable development in Canada.

The measures are listed by category of economic activity and indicator type. The Appendix provides information sources and explanatory notes for each indicator.

5.1 Resource Extraction

Agriculture

Type 1 Indicators:

1) Relative amounts of environmentally harmful and less harmful pesticides used.

2) Chemical pesticide use vs. biological control and integrated pest management (IPM).

3) Amount of use of chemically-intensive vs. organic farming.

4) Wide-row cropping vs. close-row cropping.

5) Monoculture farming vs. mixed crops.

Type 2 Indicators:

1) Total use of agricultural chemicals (pesticides and fertilizers).

2) Amount of chemicals (pesticides and fertilizers) used per unit output of agricultural products.

3) Energy consumption of different agricultural products, and the relative amounts of the different types produced.

4) Agricultural capability of land used for agriculture.

5) Cultivation of marginal land:
   - use of lower agricultural soil capability classes;
   - area of land and program expenditures for agricultural drainage projects on marginal sites.

6) Area of land used for agriculture (trends in the amount of cropland and pasture over time).

7) Use of mechanical equipment (number of tractors, combines and other equipment; tractor size; engine size and fuel efficiency) in relation to crop production (tonnages).

8) Production of field crops (tonnes).

9) Production of cattle, horses, pigs, poultry and sheep (number of animals).

Fisheries

Type 3 Indicators:

1) Commercial catch of marine and freshwater fish.

2) Fish stock assessments (biomass estimates and fishing mortality estimates).

Forestry

Type 1 Indicators:

1) Area of forest harvesting vs. area of reforestation.

2) Chemical pest control vs. biological control and integrated pest management (IPM).

3) Relative amount of use of different logging methods (clearcutting, selection and shelterwood).

4) Size of clearcuts (hectares--averages or size range for different jurisdictions).

Type 2 Indicators:

1) Amount of silviculture treatments (area treated or expenditures).

2) Area of unreforested backlog land (not satisfactorily restocked (NSR) land).

3) Ratio of the area of forest pest control to area of pest damage.

Type 3 Indicator:

1) Volume of timber harvested (cubic meters).

Type 4 Indicators:

1) Forestry inventory data: age-classes, volumes and species.

2) Species and age-class distribution in relation to the location of mills.

3) Distribution of forest productivity classes in relation to volumes of commercial tree species.

Hydroelectric development

Type 3 Indicators:

1) Number of dams constructed.

2) Area flooded by reservoirs.

3) Number of streamflow alterations and water transfers.

4) Water withdrawal and consumption by type of economic activities (cubic meters).

Hunting and trapping

Type 3 Indicators:

1) Population estimates for game animals.

2) Estimates of the legal and illegal kill.

Mineral Mining

Type 2 Indicators:

1) Rehabilitation of mine, pit and quarry sites (hectares treated and/or expenditures on rehabilitation programs of industry and government).

2) Number of mines, pits and quarries.

3) Consumption of fossil fuels by mining.

4) Consumption of electricity by mining.

5) Water withdrawal and consumption by mining.

6) Mining waste generated (tonnes):

- rock waste
- tailings
- residues

Type 3 Indicators:

1) Area of land used for mining.

2) Mineral reserves (tonnes).

3) Production of minerals by industry (tonnes), in relation to reserves:

- totals
- per capita

Fossil Fuel Development

Type 1 Indicators:

1) Production of leaded vs. lead-free gasoline (cubic meters)

2) Coal production from open-pit vs. undergound mines:

- tonnes produced
- number of facilities

3) Offshore oil and gas production vs. onshore production (cubic meters or number of wells).

4) Oil sands production vs. conventional oil production (cubic metres or number of wells).

Type 2 Indicators:

1) Oil and gas exploration activity (number of wells or number of sites being explored).

2) Number of oil and gas production facilities and coal mines.

3) Length of oil and gas pipelines constructed (per year).

4) Waste rock generation by coal mines (tonnes).

5) Pollutant loadings to water by petroleum refineries.

6) Water pollution control compliance levels of petroleum refineries (compliance with National Petroleum Effluent Regulations and Guidelines of the federal Fisheries Act; compliance with provincial regulations and guidelines).

Type 3 Indicators:

1) Reserves of oil, gas and coal.

2) Production of oil, gas and coal.

3) Depletion of oil and gas reserves:
   - oil and gas depletion index
   - oil and gas life index.

4) Ratio of production to consumption for oil, gas and coal.

5.2 Resource Processing

Chlor-alkali Industry

Type 2 Indicator:

1) Water pollution control compliance levels of chlor-alkali plants (compliance with Chlor-alkali Mercury Liquid Effluent Regulations of the federal Fisheries Act; compliance with provincial regulations and guidelines).

2) Mercury loading to water by chlor-alkali plants (kilograms).

Forest Products Processing

Type 1 Indicator:

1) Use of sulphite process vs. thermo-mechanical pulping (TMP) or chemi-thermo-mechanical pulping (CTMP) in newsprint production.

Type 2 Indicators:

1) Efficiency of pulp mills and sawmills in the use of raw material (variety in species used and size range in logs, and amount of waste generated).

2) Energy efficiency of pulp mills.

3) Use of mercury as a fungicide in pulp mills.

4) Water pollution control compliance levels of pulp mills (compliance with Pulp and Paper Effluent Regulations of the federal Fisheries Act; compliance with provincial regulations and guidelines).

5) Pollutant loadings to water by pulp mills.

Metal Smelting

Type 2 Indicators:

1) Magnitude and distribution of sulfur dioxide emissions (tonnes).

2) Trends over time in sulfur dioxide emissions (tonnes).

Manufacturing

Type 2 Indicators:

1) Number of manufacturing plants.

2) Consumption of fossil fuels by manufacturing industries.

3) Consumption of electricity by manufacturing industries.

4) Use of heavy metals by manufacturing industries.

5) Water use by manufacturing industries.

6) Hazardous waste generated by manufacturing industries (percentages among industry types).

5.3 Resource Consumption

Type 1 Indicators

1) Use of renewable vs. non-renewable energy sources.

2) Automobile use vs. use of mass transit (number of passengers x distance travelled number of vehicles).

Type 2 Indicators:

1) Motor vehicle efficiency:
   - size of vehicles (weight)
   - engine size (number of cylinders, displacement)
   - fuel efficiency (kilometers per liter).

2) Energy eficiency in building design and construction.

Type 3 Indicators:

1) Household energy consumption (number of high energy consuming household and recreational goods--clothes dryers, air conditioners, dishwashers, outboard motorboats and snowmobiles).

2) Rates of use of different types of heating fuel (number of dwellings).

3) Emissions of nitrogen oxides.

5.4 Provision of Services and Infrastructure

Government, Business and Professional Services

Type 3 Indicators:

1) Hazardous waste disposal methods used by industry (relative importance or frequency of use of municipal dumps and landfills, on-site dump or treatment, on-site storage, sewers, private dumps or landfills, or shipment to central waste handling facility).

2) Relative importance or frequency of use of recycling vs. disposal of industrial wastes.

3) Use of recycling vs. disposal for household wastes.

4) Level of treatment for domestic sewage (population served or amount of sewage treated):

- no treatment
- primary treatment
- secondary treatment
- tertiary teatment.

Generation and Supply of Electricity

Type 3 Indicators:

1) Total amount of power generated.

2) Amount of power generated by different energy sources.

3) Fuel consumption by generating stations.

4) Number of generating stations.

5) Length of transmission lines.

Transportation

Type 1 Indicators:

1) Amount of use of different transportation modes (measured in passenger-kilometers, number of passengers, aircraft movements by weight class, cargo movements through Canadian ports):

- railroads
- aircraft
- intercity bus.

2) Number, size and composition of toxic chemical spills.

Type 3 Indicators:

1) Length of roads and highways.

2) Length of railroad track.

3) Number and size of airports (size determined by land area, or number passengers or flights per day).

4) Number of motor vehicles in use.

5) Energy consumed by different transportation modes (road, rail, air and marine).

5.5 Resource Protection

Type 4 Indicators:

1) Facilities and programs for genetic conservation (expenditures, area and number of programs and facilities):

- botanical gardens and herbaria

- ecological reserves, wildlife preserves and other protected sites
- nurseries and seed banks
- zoos.

2) Representation of Canadian ecosystems in parks, ecological reserves and other protected areas.

3) Federal, provincial and territorial involvement in the Heritage Rivers System (length of river designated).

4) Distribution of endangered species and habitats in relation to parks and reserves.

6. APPLYING SUSTAINABLE DEVELOPMENT INDICATORS: AN EXAMPLE FROM THE FORESTRY SECTOR

Forestry provides a suitable model for applying the sustainable development indicators in a state of the environment report format. To determine the state and trends in suatainability of Canadian forestry, it is necessary to define sustainable forestry. Section 2 presented a set of standards for sustaining renewable resource use:

1. Harvest at levels which allow resources to be replenished without adverse environmental effects or any reduction in productivity of the resource.

2. Take into account effects on other components of the ecosystem.

3. Renew resources (by replanting, encouraging regeneration).

4. Ensure efficient resource use.

We can define sustainable forestry then, as use of the forest resource which adheres to the above standards.

The sections which follow describe an approach to apply the identified forestry indicators to each of these standards.

6.1 Forest Harvesting

Four sustainable development indicators have been identified for forest harvesting. Three of these are measures of resource stocks (the resource potentially available for harvesting):

- forest inventory data: age classes, volumes and species;
- species and age class distribution in relation to the location of mills; and
- distribution of forest productivity classes in relation to volumes of commercial tree species.

The fourth indicator is a measure of withdrawals from the resource:

- volume of timber harvested.

Tables 1 and 2 and Figures 1 to 4 show how these data may be displayed in a report. Trends suggested by the data will provide the basis for conclusions about the sustainability of forest harvesting in Canada.

Table 1

Age Class Distribution of Canadian Forests

Year	Age Class (Area in Hectares)					
	0-20	20-40	40-60	60-80	80-100	100+
1967						
1968						
1969						
1970						
1971						
1972						
1973						
1974						
1975						
1976						
1977						
1978						
1979						
1980						
1981						
1982						
1983						
1984						
1985						
1986						

Table 2

Species Composition of Canadian Forests

Year	Species (Volume in Cubic Meters)			
	Spruce	Pine	Fir	Hardwoods
1967				
1968				
1969				
1970				
1971				
1972				
1973				
1974				
1975				
1976				
1977				
1978				
1979				
1980				
1981				
1982				
1983				
1984				
1985				
1986				

Figure 1

Estimated Wood Volumes in Canadian Forests

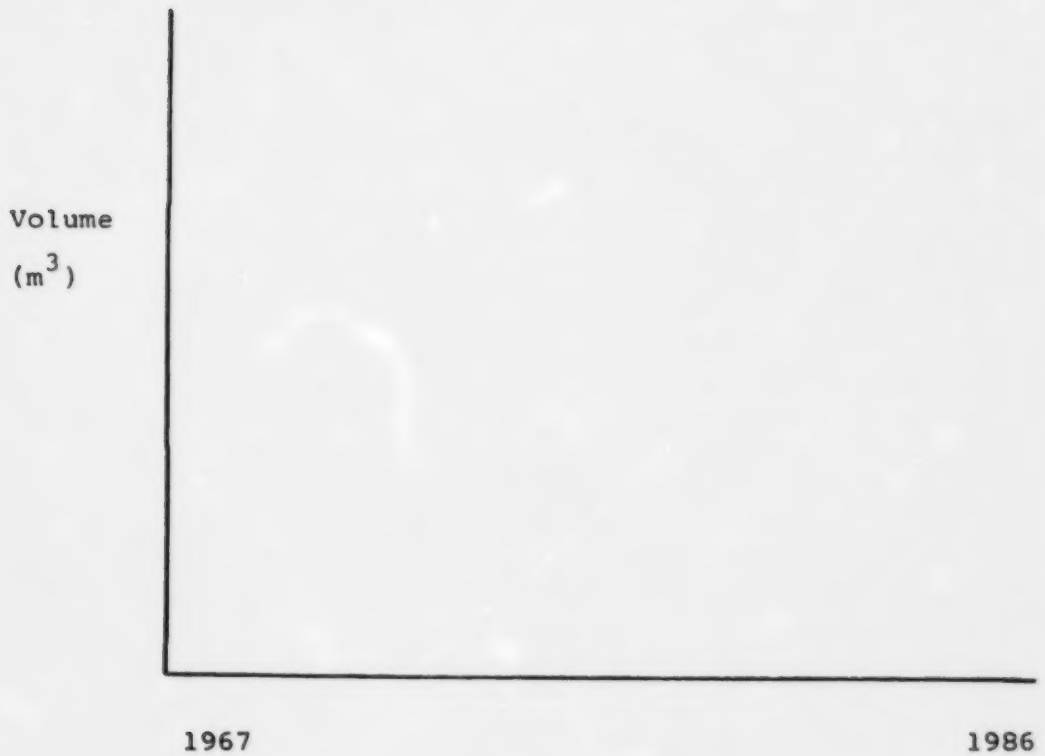

Figure 2

Distribution of Forest Productivity Classes in Relation to Volumes of Commercial Tree Species

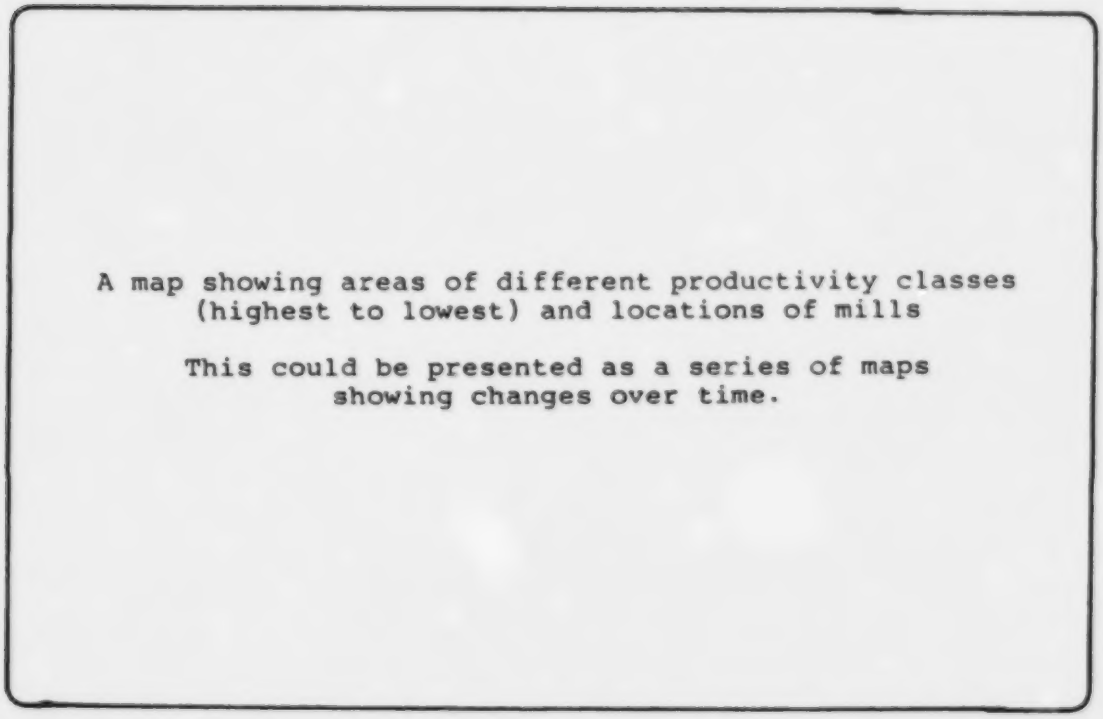
A map showing areas of different productivity classes
(highest to lowest) and locations of mills
This could be presented as a series of maps
showing changes over time.

Figure 3

Species and Age Class Distribution in Canadian Forests in Relation to Mills

A map showing areas of different age classes and forest types and locations of mills

This could be presented as a series of maps showing changes over time.

Figure 4

Volume of Wood Harvested in Canada

6.2 Effects of Forestry on Other Components of the Ecosystem

Three indicators have been suggested as measures of the ecological effects of forestry operations:

- chemical pest control vs. biological control and integrated pest management (IPM);
- relative amount of use of different logging methods (clearcutting, selection and shelterwood); and
- size of clearcuts (hectares--averages or size range for different jurisdictions).

Tables 3, 4 and 5 show how these data may be displayed in a report. Again, trends suggested by the data will provide the basis for conclusions about the sustainability of forestry in Canada.

6.3 Forest Renewal

Two measures have been suggested as indicators of the amount and effectiveness of reforestation efforts:

- area of forest harvesting vs. area of reforestation; and
- area of unreforested backlog land (not satisfactorily restocked (NSR) land).

The former is a measure of the effort applied to renew the forest, and the latter is an indicator of the net result

Table 3

Use of Different Logging Methods in Canada

Year	Logging Method (Area in Hectares)		
	Clearcutting	Shelterwood	Selection
1967			
1968			
1969			
1970			
1971			
1972			
1973			
1974			
1975			
1976			
1977			
1978			
1979			
1980			
1981			
1982			
1983			
1984			
1985			
1986			

Table 4

Average Clearcut Size, Province of -------

Year	Area in Hectares			
	0-10	10-50	50-100	100+
1967				
1968				
1969				
1970				
1971				
1972				
1973				
1974				
1975				
1976				
1977				
1978				
1979				
1980				
1981				
1982				
1983				
1984				
1985				
1986				

Table 5

Area of Pest Control in Canadian Forests (Hectares)

Year	Chemical Control	Biological Control	Integrated Pest Management
1967			
1968			
1969			
1970			
1971			
1972			
1973			
1974			
1975			
1976			
1977			
1978			
1979			
1980			
1981			
1982			
1983			
1984			
1985			
1986			

result of reforestation programs. Table 6 and Figure 5 show how these data may be displayed in a report.

6.4 Ensuring Efficient Use of the Forest Resource

Two indicators have been suggested as measures of the efficiency of forest management:

- amount of silviculture treatments (area treated or expenditures); and
- ratio of the area of forest pest control to area of pest damage.

See Tables 7 and 8.

The amount of silviculture practiced in managed forests is suggested as a measure of the efficiency of use of the resource, because silviculture can optimize the use of a particular area of forest for a particular set of objectives.

Comparing the area of pest control to the area of pest damage is a measure of the effectiveness of pest control measures. For example, evidence suggests that the area of spruce budworm infestation in New Brunswick increased during a long-term budworm control program, while the affected area in Nova Scotia decreased in the absence

Table 6

Ratio of the Area Harvested to the Area Receiving Reforestation Treatments in Canada

Year	A Area Planted, Seeded or With Site Preparation for Natural Regeneration (ha)	B Area Harvested (ha)	A/B
1967			
1968			
1969			
1970			
1971			
1972			
1973			
1974			
1975			
1976			
1977			
1978			
1979			
1980			
1981			
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1986			

Figure 5

Area of Unreforested Backlog in Canada

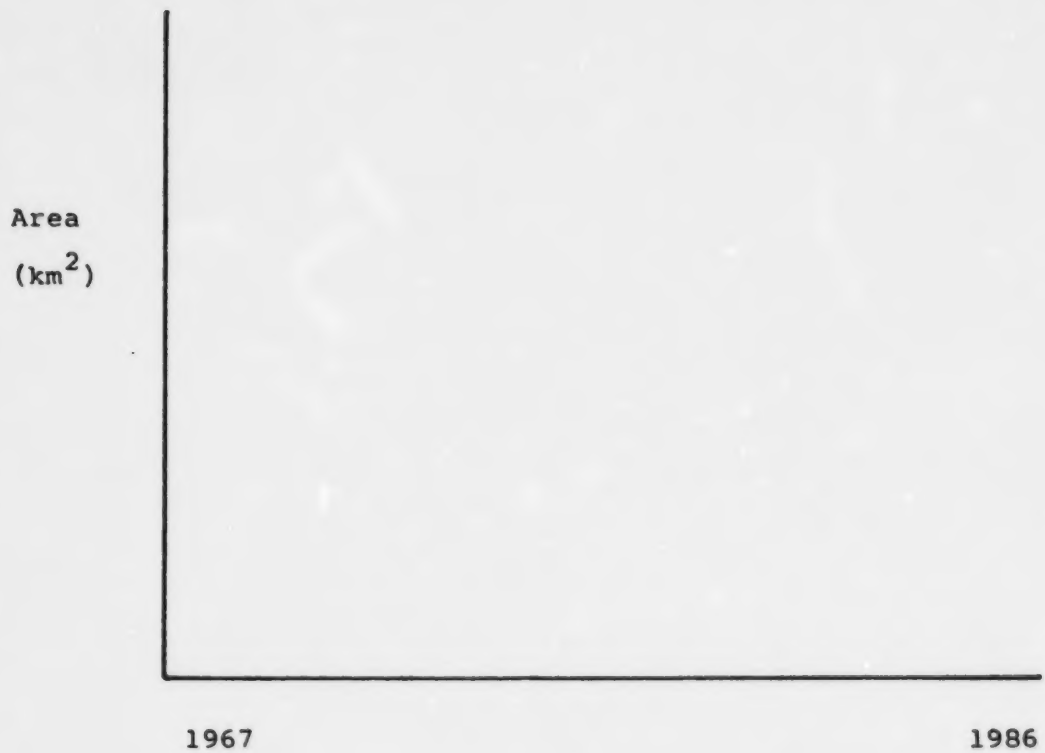

Table 7

Amount of Silviculture Treatments in Canadian Forests

Year	Area Treated (Hectares)					
	Site Preparation	Planting	Seeding	Spacing	Thinning	Other
1967						
1968						
1969						
1970						
1971						
1972						
1973						
1974						
1975						
1976						
1977						
1978						
1979						
1980						
1981						
1982						
1983						
1984						
1985						
1986						

Table 8

Ratio of the Area of Pest Control to the Area of Pest Damage in Canadian Forests

Year	A Area of Pest Control (ha)	B Area of Pest Damage (ha)	A/B
1967			
1968			
1969			
1970			
1971			
1972			
1973			
1974			
1975			
1976			
1977			
1978			
1979			
1980			
1981			
1982			
1983			
1984			
1985			
1986			

controls. This indicates that New Brunswick's spray program is not a sustainable activity.

6.5 Other Indicators of the Sustainability of Forestry

In addition to the above specific measures of performance, there are indicators for other areas of economic activity which must be addressed for an overall evaluation of the sustainability of forestry. The efficiency of resource use and the environmental impacts of forest product processing affect both the methods of forest management and the demand for wood. Thus the sustainability indicators developed for forest product processing (see Section 5.2) are relevant here.

Because forestry operations cause changes in forest ecosystems, sustainable development requires protection of Canadian forest types within parks and reserves. Thus the indicators of resource protection (Section 5.5) also relate to a state of the environment analysis of forestry.

APPENDIX

SUSTAINABLE DEVELOPMENT INDICATORS:

INFORMATION SOURCES AND EXPLANATORY NOTES

TABLE OF CONTENTS

	Page
Introduction	1
1. Resource Extraction	2
Agriculture	2
Fisheries	8
Forestry	9
Hydroelectric Development	15
Hunting and Trapping	17
Mineral Mining	18
Fossil Fuel Development	21
2. Resource Processing	26
Chlor-alkali Industry	26
Forest Products Processing	27
Metal Smelting	30
Manufacturing	30
3. Resource Consumption	33
4. Provision of Services and Infrastructure	36
Government, Business and Professional Services	36
Generation and Supply of Electricity	38
Transportation	39
5. Resource Protection	43

Introduction

This appendix provides background information for applying the sustainable development indicators described in the report. Four types of indicators are described:

1. Measures of the relative amounts, importance, or frequency of "sustainable" versus "non-sustainable" activities.

2. Measures of specific factors which indicate the sustainability of an activity.

3. Broad measures of resource consumption by society.

4. Indicators of environmental quality.

1. Resource Extraction

Agriculture

Type 1 Indicators:

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1) Relative amounts of environmentally harmful and less harmful pesticides used.

Information Source

- Agriculture Canada Pesticide Call Line: 613-993-4544 (toxicity amd environmental impact information; general information about use of a particular chemical).

- provincial departments of agriculture and the Statistics Canada Census of Agriculture (information on pesticide application permits will indicate frequency of use).

- Pesticide manufacturers and distributors could provide information on amounts produced and sold).

Comments

Toxicological and environmental impact (persistence and effect on non-target organisms) information could be used to categorize harmful and less harmful chemicals. This approach could be taken for herbicides, insecticides and rodenticides.

---

2) Chemical pesticide use vs. biological control and integrated pest management (IPM).

Information Source

- Agriculture departments in universities.

- Hall, R.H. (1981) A New Approach to Pest Control in Canada. Canadian Environmental Advisory Council, Report No. 10, Ottawa.

- provincial departments of agriculture and the Statistics Canada Census of Agriculture.

Comments

Trends in biological control and IPM are reflected by the size and number of research and development programs for these methods.

---

3) Amount of use of chemically-intensive vs. organic farming.

Information Source

- Federal and provincial departments of agriculture and the Statistics Canada Census of Agriculture provide information on pesticide use.

- Government agriculture agencies and national and provincial agriculture associations should be able to provide some information on trends in organic farming.

Comments

Information on organic farming may be scarce. An indirect measure of the importance of organic farming is the amount of health food sales. Measures could include the number of retail outlets and amount of food sold.

---

4) Wide-row cropping vs. close-row cropping.

Information Source

- Statistics Canada Census of Agriculture.

Comments

Wide-row cropping tends to use larger amounts of pesticides and has a greater soil erosion risk than close-row cropping.

---

5) Monoculture farming vs. mixed crops.

Information Source

Statistics Canada Census of Agriculture.

Comments

Monocultures are more vulnerable to destruction by a single disease or pest than mixed crops, and thus are more dependent on pesticides.

Type 2 Indicators:

---

1) Total use of agricultural chemicals (pesticides and fertilizers).

Information Source

- Agriculture Canada Pesticide Call Line: 613-993-4544 (toxicity amd environmental impact information; general information about use of a particular chemical).

- Provincial departments of agriculture and the Statistics Canada Census of Agriculture (information on pesticide application permits will inicate frequency of use).

- Pesticide manufacturers and distributors could provide information on amounts produced and sold.

Comments

The amount of chemicals used is a measure of the drain which agriculture places on resources required to produce chemical products and reflects potential impacts on the environment of agricultural activity.

---

2) Amount of chemicals (pesticides and fertilizers) used per unit output of agricultural products.

Information Source

- Agriculture Canada Pesticide Call Line: 613-993-4544 (toxicity amd environmental impact information; general information about use of a particular chemical).

- Provincial departments of agriculture and the Statistics Canada Census of Agriculture (information on pesticide application permits will indicate frequency of use).

-Pesticide manufacturers and distributors could provide information on amounts produced and sold).

- Statistics Canada Census of Agriculture.

Comments

These figures indicate resource use efficiency of agriculture. Chemical use can be compared for different types of agricultural products to determine the relative resource costs of these products.

---

3) Energy consumption of different agricultural products, and the relative amounts of the different types produced.

Information Source

- federal and provincial agriculture departments.

- Statistics Canada Census of Agriculture.

- Redcliff, M. Sustainable Development: Exploring the Contradictions, paper obtained from Strategies and Scientific Methods Section, SOE Branch, Environment Canada (provides information on energy usage by different crops).

---

4)Agricultural capability of land used for agriculture.

Information Source

- Canada Land Inventory, Land Capability for Agriculture map series.

- Statistics Canada Census of Agriculture.

- federal and provincial agriculture agencies.

Comments

A variety of indicators could be developed based on availability and use of land of different capability classes. Farm to non-farm conversion of land indicates non-sustainability. Retention of prime land in agricultural use and the designation of agricultural reserves both indicate sustainability.

---

5) Cultivation of marginal land:

- use of lower agricultural soil capability classes;
- area of land and program expenditures for agricultural drainage projects on marginal sites.

Information Source

- Canada Land Inventory.

- federal and provincial agriculture agencies.

- Canadian Wheat Board.

- Senate of Canada (1985) Soil at Risk, Ottawa.

Comments

Cultivation of marginal land can have adverse environmental effects, including the loss of wildlife habitat and the drainage of wetlands which disrupts hydrologic regimes. Figures on areas treated and expenditures under incentive programs (such as provincial drainage programs and federal Wheat Board incentives) indicate trends in sustainability of agricultural land use practices.

---

6) Area of land used for agriculture (trends over time in the area of cropland and pasture).

Information Source

Statistics Canada (1986) Human Activity and the Environment (see table 3.1.8, page 71).

Comments

Trends in the amount of land used for farming are a measure of sustainability, since the area devoted to a particular use is a measure of consumption of the land resource.

---

7) Use of mechanical equipment (number of tractors, combines and other equipment; tractor size; engine size and fuel efficiency) in relation to crop production (tonnages).

Information Source

- Statistics Canada (1986) Human Activity and the Environment (see table 3.1.8, page 71).

- manufacturers and retailers of farm equipment.

- Statistics Canada Census of Agriculture.

Comments

Trends in the amount of equipment used and energy consumption by equipment (in relation to agricultural product output) indicate sustainability of farm practices.

---

8) Production of field crops (tonnes).

Information Source

- Statistics Canada (1977) Handbook of Agricultural Statistics 1921-1974.

- Statistics Canada (1984) Handbook of Field Crop Area, Yield Production, Average Farm Price and Value, 1953-1983. working document.

---

9) Production of cattle, horses, pigs, poultry and sheep (number of animals).

Information Source

- Statistics Canada (1986) Human Activity and the Environment, page 72.

Fisheries

Type 3 Indicators:

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1) Commercial catch of marine and freshwater fish.

Information Source

- Statistics Canada (1986) Human Activity and the Environment (presents catch statistics for a number of species).

- Department of Fisheries and Oceans, Economic Development Directorate Annual Statistical Review of Canadian Fisheries. report series.

Comments

Figures on fish catch are the most widely available indicators of the condition of fisheries. While numbers of fish caught are a measure of the drain on resource stocks, the catch is heavily influenced by the market for fish products. Thus a large catch of a particular species does not necessarily indicate a healthy fish population, and a small catch does not necessarily indicate a declining population.

---

2) Fish stock assessments (biomass estimates and fishing mortality estimates).

Information Source

- Canadian Atlantic Fisheries Advisory Committee, Fisheries and Oceans Canada.

- Pacific Fisheries Scientific Advisory Committee, Fisheries and Oceans Canada.

Comments

Estimates of total fish biomass and mortality due to fishing are available for significant Canadian fisheries. This information provides a measure of the available fish stocks and indicates the drain on the resource due to human consumption of fish.

Forestry

Type 1 Indicators:

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1) Area of forest harvesting vs. area of reforestation.

Information Source

- Northern Forestry Research Centre, Forestry Canada, Edmonton (published and unpublished information from the FORSTATS program; figures are available for each province and territory).

Comments

An overall measure of forest stocks is the combined areas of 1) planting, 2) seeding and 3) site preparation for natural regeneration, expressed as a percentage of the area harvested annually. Survival rates are an important factor in assessing reforestation success. provincial agencies compile survival data but may be reluctant to release the information.

---

2) Chemical pest control vs. biological control and integrated pest management (IPM).

Information Source

- provincial forestry agencies (data on areas treated annually).

- Agriculture Canada (information on pest control methods registered for forestry).

- Forest Pest Management Institute, Forestry Canada, Sault Ste. Marie (scientific information on chemical and non-chemical controls).

---

3) Relative amount of use of different logging methods (clearcutting, selection and shelterwood).

Information Source

- Northern Forestry Research Centre, Forestry Canada, Edmonton (published and unpublished information from the FORSTATS program; figures are available for each province and territory).

- provincial forestry agencies.

Comments

Shelterwood and selection cutting are generally less environmentally disruptive than clearcutting, and thus are more sustainable. While the different cutting methods may not all be suited to a particular site, some form of shelterwood can often be sued in place of clearcutting.

---

4) Size of clearcuts (hectares--averages or size range for different jurisdictions).

Information Source

- provincial forestry agencies.

Comments

Trends in the size of clearcuts would indicate the sustainability of logging practices (smaller clearcuts would be a more sustainable practice than larger ones). Data may be difficult to obtain, although provincial agencies should have some information.

Type 2 Indicators:

---

1) Amount of silviculture treatments (area treated or expenditures).

Information Source

- Great Lakes Forestry Research Centre, Forestry Canada, Sault Ste. Marie (published and unpublished data on federal, provincial and industry expenditures).

- Northern Forestry Research Centre, Forestry Canada, Edmonton (data on area treated).

Comments

Silviculture includes site preparation, thinning,and spacing (by hand, mechanical or chemical means). These resource enhancement measures should increase the sustainability of forestry, but they will have varying degrees of environmental impact.

---

2) Area of unreforested backlog land (not satisfactorily restocked (NSR) land).

Information Source

- Petawawa National Forestry Institute, Forestry Canada, Chalk River, Ontario.

- provincial forestry agencies.

Comments

Trends in the area of NSR land are a measure of depletion of forest stocks.

---

3) Ratio of the area of forest pest control to area of pest damage.

Information Source

- federal and provincial forestry agencies.

- Swift, J. (1983) Cut and Run. Between the Lines, Toronto.

Comments

This is a measure of the effectiveness of pest control measures and thus indicates the sustainability of pest control measures. For example, Swift (1983) states that the area of spruce budworm infestation in New Brunswick increased during a long-term budworm control program, while the affected area in Nova Scotia decreased in the absence controls. This suggests that New Brunswick's spray program is not a sustainable activity.

Type 3 Indicators:

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1) Volume of timber harvested (cubic meters).

Information Source

- Canadian Forest Industries Council (1986) The Management of Canada's Forests 1986. C.F.I.C., Ottawa (provides a provincial breakdown of facts and figures on the forest industry and forest management).

- Forestry Canada, particularly the Northern Forest Research Centre, Edmonton.

- provincial forestry agencies.

- Statistics Canada, Manufacturing and Primary Industries Division. Canadian Forestry Statistics.

Comments

Annual trends indicate withdrawals from stocks of the forest resource.

Type 4 Indicators:

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1) Forestry inventory data: age-classes, volumes and species.

Information Source

- Petawawa National Forestry Institute, Chalk River (the FORSTATS program maintains a national inventory and computer data base).

- provincial forestry agencies.

Comments

Forest inventories provide several measures of the forest resource stock. Species and age-class data indicate the availability of commercially desirable trees for harvest. Volume figures can be related to annual harvest figures to guage overall sustainability of the harvest.

---

2) Species and age-class distribution in relation to the location of mills.

Information Source

- Petawawa National Forestry Institute, Chalk River (the FORSTATS program maintains a national inventory and computer data base).

- provincial forestry agencies.

Comments

For commercial forestry to be sustainable, mills must have access to adequate volumes of timber of suitable species. Volume is related to age class (the higher the age class, the higher the expected volume). Thus the sustainability of timber extraction will decrease with:

- distance to mature timber of suitable species (increasing energy consumption and environmental impact due to longer hauls for bringing logs to the mills); and
- use of lower age classes (increasing the area disturbed by logging as smaller volumes are obtained per unit area).

---

3) Distribution of forest productivity classes in relation to volumes of commercial tree species.

Information Source

- Petawawa National Forestry Institute, Chalk River (the FORSTATS program maintains a national inventory and computer data base).

- provincial forestry agencies.

Comments

Productivity classes categorize sites' capability to produce forests. Combined with wood volume data, this information indicates the condition of the forest stock available for commercial harvest.

Hydroelectric Development

Type 3 Indicators:

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1) Number of dams constructed.

Information Source

- Canadian National Committee, International Commission on Large Dams (1982) Register of Dams in Canada.

- provincial resource agencies.

Comments

Dams consume resources through raw materials used in construction and through flooding of land which is thereby removed from other land uses. Thus trends in the number of dams constructed indicate sustainability of hydroelectric development.

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2) Area flooded by reservoirs.

Information Source

- Statistics Canada (1986) Human Activity and the Environment (see Table 5.2.4, page 191).

- Inland Waters Directorate, Environment Canada.

Comments

Flooding of land for hydro development removes it from other resources and can have adverse environmental effects.

---

3) Number of streamflow alterations and water transfers.

Information Source

- Inland Waters Directorate, Environment Canada.

- Quinn, F. (1981) "Water Transfers--Canadian Style". Canadian Water Resources Journal, Vol. 6 No. 1, 1981.

- Statistics Canada (1986) Human Activity and the Environment .

Comments

Streamflow alteration and water transfers have adverse effects on water quality and aquatic habitat. Thus trends in the amount of this activity are a measure of the sustainability of hydro development.

---

4) Water withdrawal and consumption by type of economic activities (cubic meters).

Information Source

- Inland Waters Directorate, Environment Canada.

Comments

Rates of water use by different resources sectors and different types of economic activities indicate the sustainability of the activity.

Hunting and Trapping

Type 3 Indicators:

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1) Population estimates for game animals.

Information Source

- provincial and territorial wildlife agencies.

Comments

Long term population trends (numbers, and age and sex ratios) indicate health of populations and sustainability of use.

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2) Estimates of the legal and illegal kill.

Information Source

- provincial and territorial wildlife agencies.

Comments

Mortality reflects the rate of consumption of wildlife, indicating the sustainability of hunting and trapping.

Mineral Mining

Type 2 Indicators:

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1) Rehabilitation of mine, pit and quarry sites (hectares treated and/or expenditures on rehabilitation programs of industry and government).

Information Source

- aggregate producers' associations.
- Canadian Mining Association and provincial mining associations.
- Energy, Mines and Resources Canada.
- provincial resource agencies.

Comments

The objective would be to identify trends in the rehabilitation effort. Comparing the area treated with the area affected by mining (see indicator #1 of the type 3 indicators for mineral mining) would indicate sustainability of mining operations.

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2) Total number of mines, pits and quarries.

Information Source

- Department of Industry, Trade and Commerce and Regional Economic Expansion (1983) Major Projects Inventory.
- Energy, Mines and Resources Canada.
- Industry Science and Technology Canada.
- provincial resource agencies.

---

3) Consumption of fossil fuels by mining.

Information Source

- Statistics Canada (1986) Human Activity and the Environment, Table 6.1.3, page 219 (note sources for updating information).

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4) Consumption of electricity by mining.

Information Source

- Statistics Canada (1986) Human Activity and the Environment, Table 6.1.3, page 219 (note sources for updating information).

---

5) Water withdrawal and consumption by mining.

Information Source

- Inland Waters Directorate, Environment Canada.

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6) Mining waste generated (tonnes):

- rock waste
- tailings
- residues

Information Source

- Statistics Canada (1986) Human Activity and the Environment, Table 6.1.5, page 221 (note sources for updating information).

Comments

Waste can be related to ore production (see indicator #41) to obtain a measure of the efficiency of resource use.

Type 3 Indicators:

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1) Area of land used for mining.

Information Source

- Lands Directorate (1982) Mining, Land Use and the Environment, Environment Canada, Ottawa.

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2) Mineral reserves (tonnes).

Information Source

- Energy, Mines and Resources Canada.

- Statistics Canada (1986) Human Activity and the Environment, pages 150-151 (note sources for updating information).

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3) Production of minerals by industry (tonnes), in relation to reserves:

- totals
- per capita

Information Source

- Statistics Canada (1983) Historical Statistics of Canada.

- Statistics Canada. Canada's Mineral Production. report series, Catalogue No. 26-202.

Comments

Production figures indicate rates of withdrawals from the stock of resources. Relating production to reserves indicates the significance of the drain on the resource. Production per capita indicates trends in demand by society. Coupled with population trends, these figures can be used to forecast future rates of depletion.

Fossil Fuel Development

Type 1 Indicators:

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1) Production of leaded vs. lead-free gasoline (cubic meters)

Information Source

Statistics Canada (1986) Human Activity and the Environment, page 254 (note sources for updating information).

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2) Coal production from open-pit vs. undergound mines:

- tonnes produced
- number of facilities

Information Source

Energy, Mines and Resources Canada.

Comments

Open-pit mining has greater disturbance to the land, and thus greater environmental impact than underground mining. Therefore trends in the use of the different indicate sustainability of coal production.

---

3) Offshore oil and gas production vs. onshore production (cubic meters or number of wells).

Information Source

- Energy, Mines and Resources Canada.

Comments

Offshore production has greater risk of environmental damage than onshore production.

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4) Oil sands production vs. conventional oil production (cubic metres or number of wells).

Information Source

- Energy, Mines and Resources Canada.

Comments

Conventional production yields less waste than oil sands facilities, and is therefore more environmentally sound.

Type 2 Indicators:

---

1) Oil and gas exploration activity (number of wells or number of sites being explored).

Information Source

- Energy, Mines and Resources Canada.

- Statistics Canada (1986) Human Activity and the Environment, page 163.

Comments

Construction of roads, seismic lines and exploratory drilling have adverse environmental effects. Thus the amount of this activity is a measure of sustainability.

---

2) Number of oil and gas production facilities and coal mines.

Information Source

- Department of Industry, Trade and Commerce and Regional Economic Expansion (1983) Major Projects Inventory.

- Energy, Mines and Resources Canada.

- Industry Science and Technology Canada.

- provincial resource agencies.

---

3) Length of oil and gas pipelines constructed (per year).

Information Source

- Statistics Canada. Gas Utilities: Transport and Distribution Systems. report series, Catalogue No. 57-205.

- Statistics Canada. Oil Pipeline Transport. report series, Catalogue No. 55-201.

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4) Waste rock generation by coal mines (tonnes).

Information Source

- Statistics Canada. Annual Census of Coal Mines.

- Statistics Canada (1986) Human Activity and the Environment, page 222.

Comments

Waste can be related to coal production to obtain a measure of the efficiency of resource use.

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5) Pollutant loadings to water by petroleum refineries.

Information Source

- Eaton, P.B., L.P. Hildebrand and A.A. d'Entremont (1986) Environmental Quality in the Atlantic Region 1985. Environment Canada, Environmental Protection Service, Dartmouth, Nova Scotia (provides figures for a variety of pollutants regulated under the federal Fisheries Act).

- Environment Canada (1980) Status Report on Abatement of Water Pollution from the Canadian Petroleum Refining Industry. Report EPS 3-WP-83-3.

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6) Water pollution control compliance levels of petroleum refineries (compliance with National Petroleum Effluent Regulations and Guidelines of the federal Fisheries Act; compliance with provincial regulations and guidelines).

Information Source

- Eaton, P.B., L.P. Hildebrand and A.A. d'Entremont (1986) Environmental Quality in the Atlantic Region 1985. Environment Canada, Environmental Protection Service, Dartmouth, Nova Scotia (provides figures for a variety of pollutants regulated under the federal Fisheries Act).

- Environment Canada (1980) Status Report on Abatement of Water Pollution from the Canadian Petroleum Refining Industry. Report EPS 3-WP-83-3.

- Environment Canada, Conservation and Protection.

Type 3 Indicators:

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1) Reserves of oil, gas and coal.

Information Source

- Statistics Canada (1986) Human Activity and the Environment, pages 161-166 (note sources for updating information).

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2) Production of oil, gas and coal.

Information Source

- Statistics Canada (1986) Human Activity and the Environment, pages 159-163 (note sources for updating information).

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3) Depletion of oil and gas reserves:

- oil and gas depletion index
- oil and gas life index.

Information Source

- Statistics Canada (1986) Human Activity and the Environment, pages 162-167 (note sources for updating information).

Comments

The depletion index measures the percentage of initial reserves that are depleted. The life index is a measure of the remaining years of production, assuming current rates of extraction (Statistics Canada, 1986).

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4) Ratio of production to consumption for oil, gas and coal.

Information Source

- Statistics Canada (1986) Human Activity and the Environment, pages 159-169 (note sources for updating information).

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2. Resource Procesing

Chlor-alkali Industry

Type 2 Indicators:

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1) Water pollution control compliance levels of chlor-alkali plants (compliance with Chlor-alkali Mercury Liquid Effluent Regulations of the federal Fisheries Act; compliance with provincial regulations and guidelines).

Information Source

- Eaton, P.B., L.P. Hildebrand and A.A. d'Entremont (1986) Environmental Quality in the Atlantic Region 1985. Environment Canada, Environmental Protection Service, Dartmouth, Nova Scotia.

- Environment Canada, Conservation and Protection.

Comments

Mercury is an effluent of major concern with chlor-alkali plants.

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2) Mercury loading to water by chlor-alkali plants (kilograms).

Information Source

- Environmental Protection Service (1985) Status Report on Compliance with the Chlor-Alkali Liquid Effluent Regulations 1972-1983. Report EPS1/HA/I, Environment Canada, Ottawa.

Forest Products Processing

Type 1 Indicator:

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1) Use of sulphite process vs. thermo-mechanical pulping (TMP) or chemi-thermo-mechanical pulping (CTMP) in newsprint production.

Information Source

- Canadian Pulp and Paper Association, Montreal.

- Chung, Alain (1985) Investment for Competitive and Environmental Improvement in the Pulp and Paper Industry. unpublished report, Commercial Chemicals Analysis Division, Conservation and Protection, Environment Canada, Ottawa.

- Environment Canada, Conservation and Protection.

Comments

TMP and CTMP result in improved wood fiber utilization, with less fiber loss in mill effluents than with the sulphite process.

Type 2 Indicators:

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1) Efficiency of pulp mills and sawmills in the use of raw material (variety in species used and size range in logs, and amount of waste generated).

Information Source

- Canadian Forest Industries Council.

- Canadian Pulp and Paper Association.

Comments

The capability to use a variety of species and sizes of logs indicates efficient use of raw material and a reduced tendency to high-grade the forest.

The amount of waste wood and fiber resulting from milling is a measure of the efficiency of resource use.

---

2) Energy eficiency of pulp mills.

Information Source

- Canadian Pulp and Paper Association, Montreal.

- Chung, Alain (1985) Investment for Competitive and Environmental Improvement in the Pulp and Paper Industry. unpublished report, Commercial Chemicals Analysis Division, Conservation and Protection, Environment Canada, Ottawa.

- Energy, Mines and Resources Canada, Forest Industrial Renewable Energy Program.

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3) Use of mercury as a fungicide in pulp mills.

Information Source

- Eaton, P.B., L.P. Hildebrand and A.A. d'Entremont (1986) Environmental Quality in the Atlantic Region 1985. Environment Canada, Environmental Protection Service, Dartmouth, Nova Scotia.

- Canadian Pulp and Paper Association, Montreal.

Comments

Mercury was used as a fungicide in pulp mills until the 1960's. Its use had adverse effects on aquatic ecosystems.

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4) Water pollution control compliance levels of pulp mills (compliance with Pulp and Paper Effluent Regulations of the federal Fisheries Act; compliance with provincial regulations and guidelines).

Information Source

- Eaton, P.B., L.P. Hildebrand and A.A. d'Entremont (1986) Environmental Quality in the Atlantic Region 1985. Environment Canada, Environmental Protection Service, Dartmouth, Nova Scotia.1) Canadian Pulp and Paper Association, Montreal.

- Environmental Protection Service (1984) Status Report on Abatement of Water Pollution from the Canadian Pulp and Paper Industry (1982) Report EPS/1/PF/1, Environment Canada, Ottawa.

- Environment Canada, Conservation and Protection.

- Statistics Canada (1986) Human Activity and the Environment, page 237.

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5) Pollutant loadings to water by pulp mills.

Information Source

- Chung, Alain (1985) Investment for Competitive and Environmental Improvement in the Pulp and Paper Industry. unpublished report, Commercial Chemicals Analysis Division, Conservation and Protection, Environment Canada, Ottawa.

- Environment Canada, Conservation and Protection.

- Environmental Protection Service (1984) Status Report on Abatement of Water Pollution from the Canadian Pulp and Paper Industry (1982) Report EPS/1/PF/1, Environment Canada, Ottawa.

- Statistics Canada (1986) Human Activity and the Environment, page 236.

Metal Smelting

Type 2 Indicators:

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1) Magnitude and distribution of sulfur dioxide emissions (tonnes).

Information Source

Environment Canada, Conservation and Protection.

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2) Trends over time in sulfur dioxide emissions (tonnes).

Information Source

- Environment Canada, Conservation and Protection.

- Statistics Canada (1986) Human Activity and the Environment, page 267.

Manufacturing

Type 2 Indicators:

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1) Number of manufacturing plants.

Information Source

- Statistics Canada (1986) Human Activity and the Environment, page 226 (note sources for updating information).

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2) Consumption of fossil fuels by manufacturing industries.

Information Source

- Statistics Canada (1986) Human Activity and the Environment, page 231 (note sources for updating information).

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3) Consumption of electricity by manufacturing industries.

Information Source

- Statistics Canada (1986) Human Activity and the Environment, page 231 (note sources for updating information).

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4) Use of heavy metals by manufacturing industries.

Information Source

- Statistics Canada (1986) Human Activity and the Environment, page 233 (note sources for updating information).

Comments

The amount of raw materials used is a measure of the sustainability of resource use.

Heavy metals have adverse effects on the environment, and the extent of their use indicates the degree of threat.

---

5) Water use by manufacturing industries.

Information Source

- Statistics Canada (1986) Human Activity and the Environment, page 234 (presents figures for different industry groups).

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6) Hazardous waste generated by manufacturing industries (percentages among industry types).

Information Source

- Statistics Canada (1986) Human Activity and the Environment, page 235 (presents figures for different industry groups).

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3. Resource Consumption

Type 1 Indicators:

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1) Use of renewable vs. non-renewable energy sources.

Information Source

- Bott, R., D. Brooks and J. Robinson (1983) Life After Oil: A Renewable Energy Policy for Canada. Friends of the Earth, Ottawa.

- Energy, Mines and Resources Canada.

---

2) Automobile use vs. use of mass transit (number of passengers x distance travelled; number of vehicles).

Information Source

- Statistics Canada.

- Transport Canada.

Type 2 Indicators:

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1) Motor vehicle efficiency:

- size of vehicles (weight)
- engine size (number of cylinders, displacement)
- fuel efficiency (kilometers per liter).

Information Source

- motor vehicle manufacturers.

- Statistics Canada.

- Transport Canada.

Comments

Trends in efficiency of resource use in manufacture and operation of motor vehicles is a measure of sustainability.

---

2) Energy eficiency in building design and construction.

Information Source

- Energy, Mines and Resources Canada.

Comments

Trends in the energy efficiency of buildings are a measure of the sustainability of urban development.

Type 3 Indicators:

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1) Household energy consumption (number of high energy consuming household and recreational goods--clothes dryers, air conditioners, dishwashers, outboard motorboats and snowmobiles).

Information Source

- Statistics Canada. Household Facilities and Equipment. report series, Catalogue No. 64-202.

---

2) Rates of use of different types of heating fuel (number of dwelings).

Information Source

- Statistics Canada (1986) Human Activity and the Environment, page 258 (note sources for updating information).

Comments

Rates of use of different fuels indicate trends in depletion of the different types, and fuels differ in type and degree of environmental impact.

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3) Emissions of nitrogen oxides.

Information Source

- Environment Canada, Conservation and Protection.

Comments

Trends in emissions of nitrogen oxides indicate the degree of threat from acid rain and thus are a measure of the sustainability of motor vehicle use.

---

4. Provision of services and Infrastructure

Government, Business and Professional Services

Type 3 Indicators:

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1) Hazardous waste disposal methods used by industry (relative importance or frequency of use of municipal dumps and landfills, on-site dump or treatment, on-site storage, sewers, private dumps or landfills, or shipment to central waste handling facility).

Information Source

- Eaton, P.B., L.P. Hildebrand and A.A. d'Entremont (1986) Environmental Quality in the Atlantic Region 1985. Environment Canada, Environmental Protection Service, Dartmouth, Nova Scotia.

- Environment Canada, Conservation and Protection.

- provincial environment departments.

Comments

Disposal methods differ in degree of environmental impact, with use of sewers being most hazardous and suitable on-site or centralized treatment facilities being least damaging.

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2) Relative importance or frequency of use of recycling vs. disposal of industrial wastes.

Information Source

- Campbell, D. (1983) "Present and Future Trends in Resource Recovery". Recoup, Vol. 3, No. 2, pp. 32-34.

- Campbell, M.E. and W.M. Glenn (1982) Profit from Pollution Prevention. Pollution Probe Foundation, Toronto.

- Canadian Association of Recycling Industries.

- Environment Canada, Conservation and Protection.

- provincial environment departments.

---

3) Use of recycling vs. disposal for household wastes.

Information Source

- Campbell, D. (1983) "Present and Future Trends in Resource Recovery". Recoup, Vol. 3, No. 2, pp. 32-34.

- Campbell, M.E. and W.M. Glenn (1982) Profit from Pollution Prevention. Pollution Probe Foundation, Toronto.

- Canadian Association of Recycling Industries.

- Environment Canada, Conservation and Protection.

- provincial environment departments.

---

4) Level of treatment for domestic sewage (population served or amount of sewage treated):

- no treatment
- primary treatment
- secondary treatment
- tertiary teatment.

Information Source

- provincial environment departments.

- Statistics Canada (1986) Human Activity and the Environment, page 256 (note sources for updating information).

Generation and Supply of Electricity services

Type 3 Indicators:

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1) Total amount of power generated.

Information Source

- Statistics Canada. Electric Power Statistics. report series, Catalogue No. 57-202.

Comments

Trends in the amount of power generated are a measure of resource consumption

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2) Amount of power generated by different energy sources.

Information Source

- Statistics Canada. Electric Power Statistics. report series, Catalogue No. 57-202.

Comments

Power generation ethods differ in environmental impact and in relative use of renewable and non-renewable resources.

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3) Fuel consumption by generating stations.

Information Source

- Statistics Canada (1986) Human Activity and the Environment, pages 241-243 (note sources for updating information).

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4) Number of generating stations.

Information Source

- Statistics Canada. Electric Power Statistics. report series, Catalogue No. 57-202.

- Statistics Canada (1986) Human Activity and the Environment, page 245.

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5) Length of transmission lines.

Information Source

- Statistics Canada. Electric Power Statistics. report series, Catalogue No. 57-202.

Comments

Construction of transmission lines consumes natural resources and has environmental impacts. Thus trends in the length of transmission lines constructed is a measure of the sustainability of supplying electricity.

Transportation

Type 1 Indicators:

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1) Amount of use of different transportation modes (measured in passenger-kilometers, number of passengers, aircraft movements by weight class, cargo movements through Canadian ports):

- railroads
- aircraft
- intercity bus.

Information Source

- Statistics Canada (1986) Human Activity and the Environment, pages 248-252 (note sources for updating information).

Comments

Relative use of personal automobiles and various forms of mass transit indicate sustainability when related to the different levels of energy use and emissions of pollutants which characterize the different transportation modes.

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2) Number, size and composition of toxic chemical spills.

Information Source

- Eaton, P.B., L.P. Hildebrand and A.A. d'Entremont (1986) Environmental Quality in the Atlantic Region 1985. Environment Canada, Environmental Protection Service, Dartmouth, Nova Scotia (provides figures for a variety of pollutants regulated under the federal Fisheries Act).

- Environment Canada, Conservation and Protection.

Comments

Trends in the number, size and composition of toxic spills indicate teh degree of environmental hazard associated with transport of dangerous goods.

Type 3 Indicators:

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1) Length of roads and highways

Information Source

- Statistics Canada. Report on Federal, Provincial and Territorial Roads and Highways--Length and Expenditures. report series, Catalogue No. 53-006.

Comments

Construction of roads and highways consumes natural resources and has environmental impacts. Thus trends in the length of roads and highways constructed indicate sustainability of transportation development.

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2) Length of railroad track.

Information Source

- Statistics Canada. Railway Transport, Part III, report series, Catalogue No. 52-209.

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3) Number and size of airports (size determined by land area, or number of passengers or flights per day).

Information Source

- Statistics Canada (1986) Human Activity and the Environment, page 201.

- Transport Canada.

Comments

Construction and operation of airports consumes natural resources and has environmental impacts and thus is a measure of the sustainability of transportation development.

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4) Number of motor vehicles in use.

Information Source

- Statistics Canada. Road Motor Vehicles: Registrations. report series, Catalogue No. 53-219.

Comments

Trends in the number of motor vehicles indicate the rate of consumption of renewable and non-renewable resources. This information may be combined with data on fuel efficiency and emission levels to reflect environmental impact trends involving motor vehicle transport.

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5) Energy consumed by different transportation modes (road, rail, air and marine).

Information Source

- Statistics Canada (1986) Human Activity and the Environment, page 252 (note sources for updating information).

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5. Resource Protection

Type 4 Indicators:

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1) Facilities and programs for genetic conservation (expenditures, area and number of programs and facilities):

- botanical gardens
- ecological reserves, wildlife preserves and other protected sites
- herbaria
- nurseries
- seed banks
- zoos.

Information Source

- Canadian Council on Ecological Areas.

- Environment Canada, Canadian Parks Service and Canadian Wildlife Service.

- Forestry Canada.

- provincial departments of natural resources.

Comments

Trends in the development of these facilities and programs will indicate the degree of effort expended to conserve genetic resources.

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2) Representation of Canadian ecosystems in parks, ecological reserves and other protected areas.

Information Source

- Canadian Council on Ecological Areas.

- Environment Canada, Canadian Parks Service and Canadian Wildlife Service.

- International Biological Programme (IBP).

- provincial departments of natural resources.

Comments

The objective would be to determine how much of Canada's variety of natural features and ecosystems falls within parks and reserves. This would require an ecological land classification system applied to the Canadian landscape and determining which of the identified ecological units fall within parks and reserves. One approach would involve mapping subunits of the ecozone system used for the Canadian SOE reporting program, and determining their distribution relative to parks and reserves. Another approach could use existing IBP mapping to define ecosystems and natural features, determining which of the Canadian IBP sites (surveyed in the late 1960s and early 70s) have been protected in parks and reserves.

Parks and reserves vary in the degree of protection provided to the natural features they contain. This variability will affect the degree of "sustainability" of economic development as measured by this indicator.

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3) Degree of federal, provincial and territorial involvement in the Heritage Rivers System (length of river designated).

Information Source

- Heritage Rivers Program, Canadian Parks Service, Environment Canada, Ottawa.

Comments

As with parks and reserves rivers within the Heritage Rivers System vary in the degree of protection provided by the particular jurisdiction.

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4) Distribution of endangered species and habitats in relation to parks and reserves.

Information Source

- Canadian Council on Ecological Areas.

- Committee on the Status of Endangered Wildlife in Canada. Status Reports on listed species. Canadian Nature Federation, Ottawa.

- Environment Canada, Canadian Parks Service and Canadian Wildlife Service.

- provincial wildlife agencies.